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# Table of Contents

## M Chassis and Suspension

Subject	Page
<b>E60 M5</b> .....	<b>5</b>
Body .....	5
Suspension Components .....	6
EDC-K .....	7
Selecting Program .....	7
Brakes .....	8
Rotors .....	8
Calipers .....	9
Dynamic Stability Control (DSC) .....	10
Operating Modes of the MK60E5 .....	11
MDynamic Mode (MDM) .....	11
Hill Ascent Assistant .....	11
Condition Based Service (CBS) .....	11
System Components .....	13
Sensors .....	13
Control Unit .....	13
Hydraulic Unit .....	13
Pressure Generation .....	13
Engine Intervention .....	13
Interfaces .....	13

---

# Table of Contents

Subject	Page
<b>E90 M3</b> .....	<b>14</b>
Double-jointed Spring Strut Front Axle .....	15
Front Axle Carrier .....	15
Swivel Bearing .....	16
Spring Strut .....	16
Tension Strut .....	18
Wishbone .....	18
Wheel Bearing Unit .....	18
Front Anti-roll Bar .....	18
Steering System .....	19
Rear Axle .....	20
Wheel Carrier .....	21
Toe Struts .....	21
Camber Struts .....	21
Wishbone .....	21
Control Strut .....	21
Traction Strut .....	21
Rear Shock Absorbers .....	21
Electronic Damper Control - Continuous (EDC-K) .....	22
EDC-K System Circuit Diagram .....	23
Wheels and Tires .....	24
Wheel/tire Specification .....	24
Brakes .....	24
Brake System Specification .....	24
Dynamic Stability Control (DSC) MK60E5 .....	25

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## Table of Contents

Subject

Page

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PAGE

# M Chassis and Suspension

**Model: E60 M5, E63/64 M6 and E9x M models**

**Production: From Start of Production**

## OBJECTIVES

After completion of this module you will be able to:

- Identify the changes made to the suspensions of the M5, M6 and M3 when compared to the series production vehicles.
- Explain the components used in the steering system of the M5, M6 and M3.
- Identify the version of DSC used in the different M models.
- Identify the braking system upgrades made to the M vehicles when compared to series production vehicles.

# E60 M5

## Body

The E60 M5 utilizes the same body construction as the production based 5 Series E60. The main body is made of steel and the front end utilizes the familiar GRAV technology.

GRAV or "gewichtsreduzierter aluminiumvorderbau" is a lightweight aluminum front end which enhances the lightweight

design of the vehicle. Almost the entire front end is made of aluminum.

The transition to steel in the composite construction starts in the vicinity of the engine bulkhead. The reduced weight of the front end in particular contributes much to the ideal axle-load distribution of 50:50.

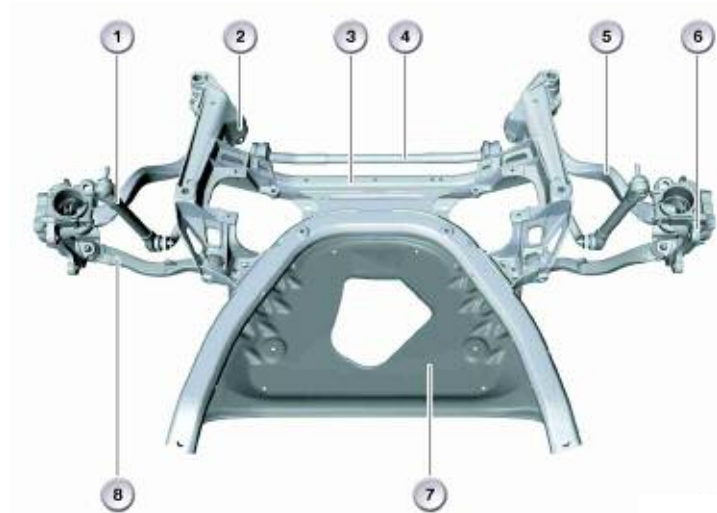


## Suspension Components

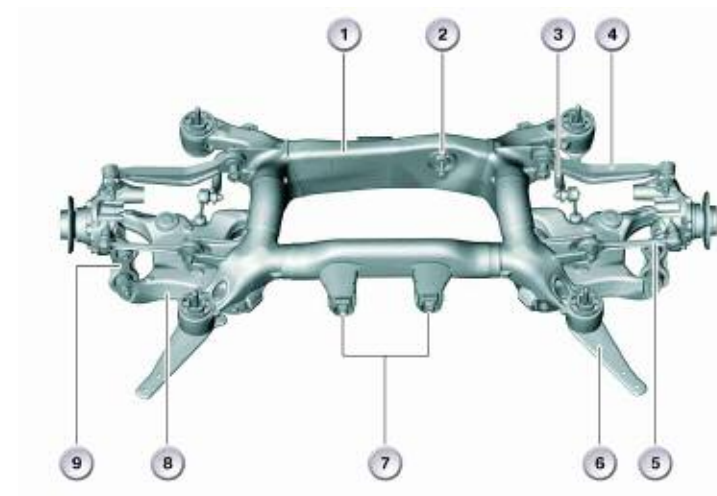
The control arms and transverse links are made of aluminum and ensure high-precision tracking of the wheels. The highly innovative design principle with the special layout of the leading links and

control arms ensures high-precision steering. The low axle loads, especially in the area of the front axle, also provide for a high degree of agility and familiar BMW handling characteristics.

**Front Axle**



Index	Explanation
1	Stabilizer Link
2	Hydro-Mount
3	Front Axle Carrier
4	Stabilizer Bar (No ARS)
5	Tension Strut
6	Swivel Bearing
7	Reinforcement Plate
8	Control Arm



Index	Explanation
1	Axle Carrier
2	Differential Bearing, rear
3	Stabilizer Bar
4	Control Arm
5	Traction Strut
6	Thrust Rod
7	Differential Bearing, front
8	Swinging Arm
9	Integral Link

**Rear Axle**

## EDC-K

The continuously variable electronic damping control (EDC-K) system used in the E65/66 is used in the E60 M5.

The continuous Electronic Damping Control (EDC-K) absorbs vertical forces while driving and dampens these forces to the chassis.

The forces are measured by two vertical acceleration sensors on the front axle (left and right) and one at the rear axle (right). The front sensors are located in the wheel housings and the rear on the trunk tray underneath the trunk ventilation ports. The dampening characteristics are mapped in the control module to continuously regulate the EDC-K providing maximum comfort.

The EDC-K works with infinitely variable valves in the dampers to regulate the hydraulic fluid flow using electromagnetic control valves. EDC-K provides the actual damping force required at any time.

The steering angle sensor is used along with the front wheel speed sensors to determine the lateral acceleration.

The controller provides the opportunity to select from three basic settings:

- “Comfort”** - Comfort-oriented coordination of shock absorbers and steering
- “Normal”** - Offers a balanced mixture of the comfort and the sports program
- “Sport”** - Consistently sporty coordination of shock absorbers and steering.

## Selecting Program

To select between the three programs available, press the EDC button repeatedly:

**“Comfort”**: No LED lights up in the button.

**“Normal”**: One LED lights up in the button.

**“Sport”**: Both LEDs light up in the button.

The last selected program is active each time the engine is started.

You can also activate your preferred program with the button on the steering wheel.



**Note:** For further information regarding vehicle settings refer to the Performance Controls section of this training material or the Vehicle Owner’s Manual.

## Brakes

The M5 has braking distances equal to top sports car levels. The new BMW M5 owes its enormous braking power to double piston aluminum brake calipers and perforated, ventilated compound (floating) brake rotors.

The braking distance for the M5 is approximately 118ft from 62 mph to a full stop.



**Front rotor of E60 M5**

The front rotors measurements are 374 x 36 mm. The rear rotors measure 370 x 24 mm.

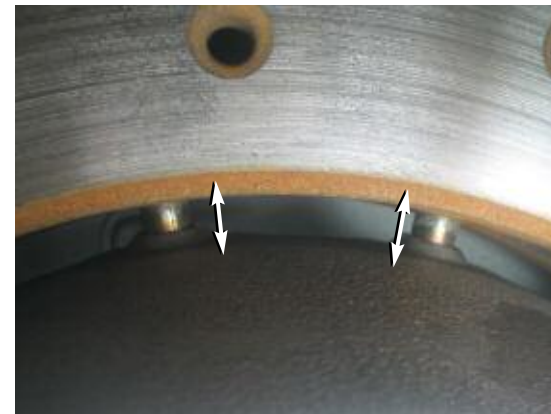


**Rear rotor of E60 M5**

## Rotors

Both the front and rear rotors are cross drilled floating type. These ensure optimized heat dissipation, improved response, as well as reduction of unsprung masses.

The rotor has an aluminum center section (hub) with pins embedded in a radial pattern that are “connected” to the rotor surface utilizing a free moving or floating configuration. This allows the rotor surface to contract and expand with the changes in temperature.



**Detail of Rotor Attachment Pins**



**Detail of Rotor Alignment Pins on Hub**



The rotor is attached to the hub with two allen style screws and three alignment pins located on the hub.

The rotor outer ring is cast and holes are drilled out to improve braking. The drilled surface allows gases that form between the brake pad and rotor to escape. Otherwise, there would be a thin film of “brake gases” between the surface of the rotor and the brake pads.

Brake pads are made by gluing the friction material to a backing plate (metal). These are then baked in an oven to allow the glue to cure. While the brakes are heated, gasses are released and travel through the brake pads to the surface. This can be seen on any new brake pads as a lighter upper section of the brake pad (see picture below).



**Rear Brake Pads (“gasses”)**

## Calipers

The M5 utilizes dual piston brake calipers in the front and conventional single piston calipers in the rear.



**Dual Piston Front Brake Caliper**



**Dual Piston Front Brake Caliper (close-up view)**

## Dynamic Stability Control (DSC)

The E60 M5 is equipped with the Continental Teves Dynamic Stability Control System (DSC+) MK60E5. Although all E6x vehicles were updated to the Bosch traction control and stability system DSC8+ from 09/2005, the M5 still uses the Teves system.

The MK60E5 system is also used in the E9x M3. The system is a further development of the MK60psi system. The abbreviation "psi" stands for "pressure sensor integrated" i.e. the two pressure sensors of the tandem master brake cylinder (THZ) have been combined to form one plausibility sensor and integrated in the hydraulic unit.

The designation "E5" in MK60E5 signifies the 5 pressure sensors that are integrated in the hydraulic unit: One pressure sensor that

measures the pressure from the tandem master brake cylinder THZ and four further sensors that measure the braking pressure of the respective wheel brake.

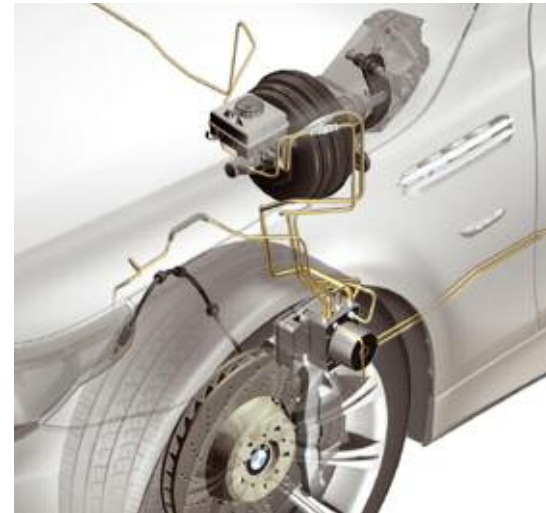
This system offers functions that were not yet available with the previous system.

MK60E5 added the following functions:

- Brake Readiness
- Dry Braking
- Hill Ascent Assistant

The features of this system distinctly enhance comfort during control intervention while facilitating even more precise individual wheel braking in connection with the analog control valves.

This system made it possible to reduce the required braking distance compared to previous systems. The E60 M5 has a braking distance of less than 118 feet from a speed of 62 mph (< 36 m from 100 km/h).



**Mounting Location of DSC Control Unit and Hydraulic Unit**

Compared to the standard DSC features, the MK60E5 in the E60 M5 has been upgraded by the following additional functions:

- MDynamic Mode (MDM is activated via the M-Drive)
- Brake readiness (Brake Standby)
- Dry braking
- Hill ascent assistant

The following functions are not used on the M5:

- Performance control (FLR)
- Soft stop
- Fading brake support (FBS)
- Dynamic traction control (DTC)

### **Operating Modes of the MK60E5**

In principle, the MK60E5 has 3 different operating modes:

- DSC ON
- DSC OFF
- MDynamic mode

There is no DTC function in connection with the M5. However, similar to DTC mode, corresponding control thresholds are raised by activating the MDM.

#### **■ MDynamic Mode (MDM)**

MDM gives the performance-oriented driver the option of driving the car with controlled float angle and longitudinal slip without DSC intervening. The control system intervenes only when the physical limits are exceeded. MDM is activated via the M-Drive.

The control thresholds are not static but rather, as the speed increases, they approach the thresholds of DSC ON mode.

The stability control thresholds are identical as from a speed of approximately 125 mph (200 km/h) in order not to overtax the driver in the high speed range.

#### **■ Hill Ascent Assistant**

Assistance is provided when driving off on uphill gradients by briefly maintaining a specific brake pressure in the wheel brakes. This function is active only when the transmission is not in "N" position and the handbrake is released.

DSC ON/OFF has no influence in this case.

The tilt angle (uphill and downhill gradient) is calculated from the measured value of the longitudinal acceleration sensor. The DSC calculates the necessary holding pressure based on the uphill or downhill gradient.

After releasing the brake pedal, the braking pressure is immediately decreased to the calculated holding pressure which is then reduced in stages after a maximum time delay of 0.7 seconds. The vehicle will start off after approximately 1 seconds if the driver does not press the accelerator pedal.

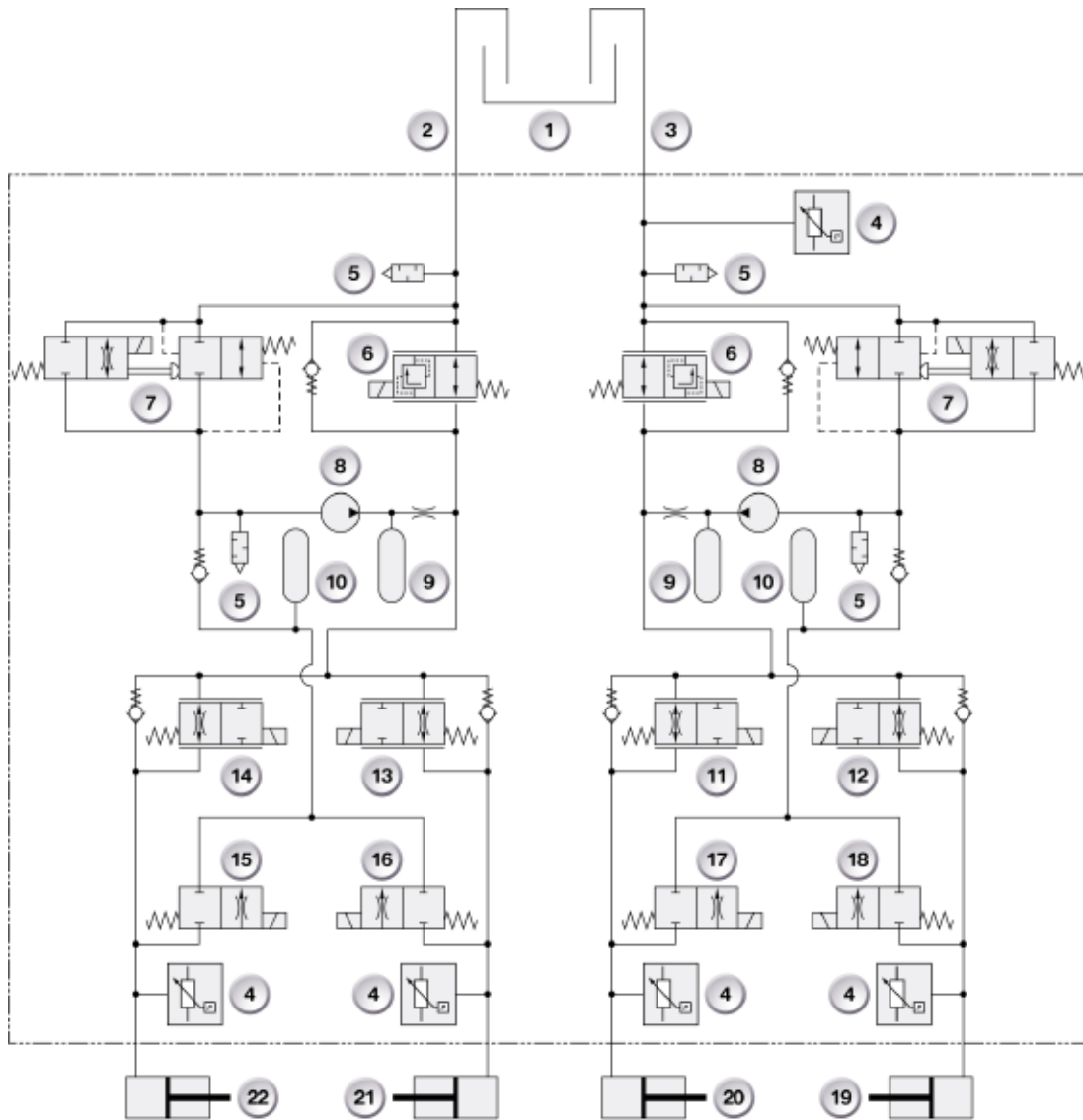
The longitudinal acceleration sensor is assigned to the SMG system. The DSC control unit receives this signal over the bus network.

#### **Note: This function is also active on an incline with reverse gear engaged**

#### **■ Condition Based Service (CBS)**

The MK60E5 calculates and evaluates the condition of the brake pads. In contrast to the E60 Series, the M5 is equipped with two brake pad sensors on the front axle.

**DSC MK60E Hydraulics Diagram**



Index	Explanation
1	Brake Fluid Reservoir
2	Rear Axle
3	Front Axle (hydraulic connection)
4	Pressure Sensor, push rod circuit
5	Pulsation Damper
6	Isolating Valve
7	Electric Changeover Valve
8	Self-Priming Return Pump
9	Damper Chamber
10	Accumulator Chamber
11	Front Left Inlet Valve with Orifice Plate, analog
12	Front Right Inlet Valve with Orifice Plate, analog
13	Rear Right Inlet Valve, analog
14	Rear Left Inlet Valve, analog
15	Rear Left Outlet Valve
16	Rear Right Outlet Valve
17	Front Left Outlet Valve
18	Front Right Outlet Valve
19	Front Right Wheel Brake
20	Front Left Wheel Brake
21	Rear Right Wheel Brake
22	Rear Left Wheel Brake

## System Components

The predominant differences in the design of MK60E5 compared to MK60psi are:

- Analog valves
- 4 pressure sensors for individual braking pressure acquisition at each wheel.

### ■ Sensors

Sensor system	Principle	Manufacturer
Active wheel speed sensors	Magneto-resistive principle	Teves
Steering angle sensor (LWS) in steering column switch cluster (SZL)	Basic sensor, potentiometer technology	
Yaw rate sensor	Double tuning fork principle	
Lateral acceleration sensor	Capacitive principle	VTI
5 pressure sensors	Piezoresistive (change in resistance in piezo)	
Brake light switch	Hall principle	
Brake fluid level switch	Reed contact switch	

### ■ Control Unit

The control unit is mounted behind the left front wheel well cover and is attached to the hydraulic unit. It consists of:

- Add-on control unit
- Integrated semiconductor relay (motor and valve relay).

### ■ Hydraulic Unit

The Teves MK60E5 hydraulic unit consists of:

- Front axle
  - 2 analog inlet valves
  - 2 high-speed outlet valves
  - 1 isolating valve
  - 1 changeover valve
- Rear axle
  - 2 analog inlet valves
  - 2 high-speed outlet valves
  - 1 isolating valve
  - 1 changeover valve

### ■ Pressure Generation

- Pump with two differential piston pump elements
- Operated by means of common eccentric shaft
- 250 W pump motor
- ASC and DSC mode: Self-priming return pump

### ■ Engine Intervention

- Ignition timing adjustment
- Charge control

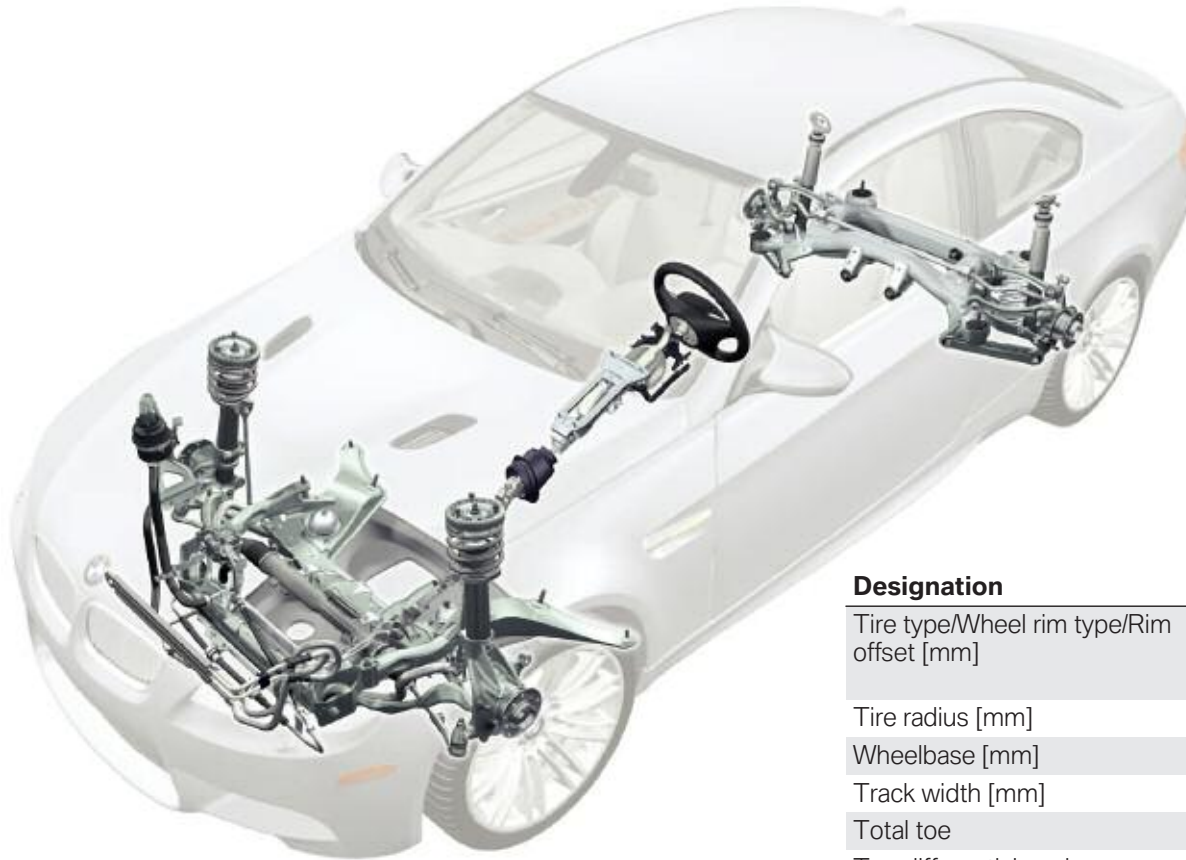
### ■ Interfaces

- CAN-bus interface (F-CAN, PT-CAN)



## E90 M3

The chassis of the E9X M3 is based on the chassis of the E9X series models respectively. All modifications are described in this section.



Designation	E92 M3	Series E92 335i
Tire type/Wheel rim type/Rim offset [mm]	245-40 ZR 18/8.5Jx18/IS29	225-45 WR 17 RSC/8Jx17/IS34
Tire radius [mm]	305	295
Wheelbase [mm]	2761	2760
Track width [mm]	1538	1500
Total toe	16'	14'
Toe differential angle	2° 14'	1° 40'
Camber	-1°	-18'
Kingpin inclination	15° 2'	14° 7'
Kingpin offset [mm]	8.4	5.1
Trail [mm]	29.4	20.3
Trail angle	7° 8'	7° 5'

### E92 M3 Chassis

## Double-jointed Spring Strut Front Axle

### Complete front axle



### Wheel suspension components



Index	Explanation	Index	Explanation
1	Rubber mount for tension strut	4	Wheel hub
2	Tension strut	5	Wishbone
3	Swivel bearing	6	Front axle carrier

## Front Axle Carrier

The front axle carrier is an aluminum alloy construction. In order to ensure optimum strength and torsional rigidity, a high-pressure forming technique has been used to manufacture certain sections.

Aluminum has been chosen for its lightweight and strength properties. The components of the front axle are joined together by an aluminum welding process.

### Front axle carrier



## Swivel Bearing

The 'M' swivel bearing is completely new. The bearing is made from an aluminum cast alloy, which reduces the weight by 500 grams.

The following changes have been made to the front wheel carrier:

- Adjusted dimensions for the larger 'M' wheel.
- As described below, the method by which the spring strut is clamped into the swivel bearing has been changed.
- The geometric fixing points for the wishbone, tension strut and steering track rod have been selected to ensure optimum sports vehicle kinematics.
- Modified mounting position for the larger brake caliper.



Index	Explanation
1	Clamp connection of the spring strut support
2	Attachment points for the tension strut, wishbone and steering track rod
3	Brake caliper mounting

## Spring Strut

The front steel suspension spring has a 95 mm compression and 100 mm rebound travel.

A new spring concept supports lateral chassis stability. Depending on the vehicle weight (equipment), modified spring types are used.

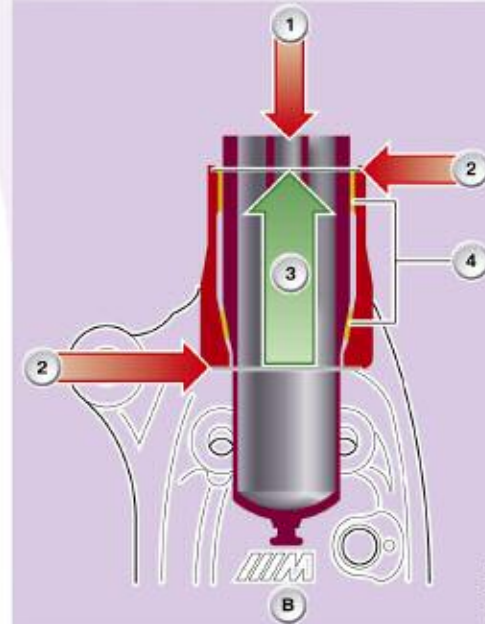
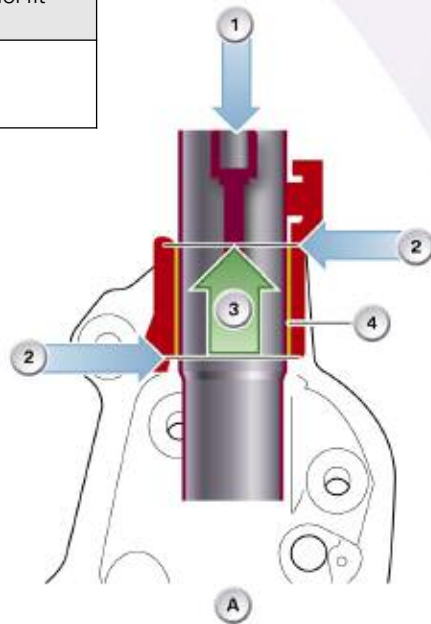


Index	Explanation
1	Retaining nut, shock absorber to support bearing
2	Dowel pin, support bearing to body
3	Mounting fixture, support bearing to body
4	Joint seat
5	Support bearing
6	Upper spring seat
7	Support disc
8	Additional damper/spring
9	Gaiter
10	Lower spring seat
11	Spring strut



**Spring strut connection to the wheel carrier compared to the E9x series models**

Index	Explanation
A	Spring strut support in the E9x series model
1	Vertical force (Z-axis)
2	Upper and lower limit for supporting lateral and longitudinal force (X and Y axis)
3	Clamp height 52 mm parallel fit
4	Parallel contact face



Index	Explanation
B	Spring strut support in the E9x M3
1	Vertical force (Z-axis)
2	Upper and lower limit for supporting lateral and longitudinal force (X and Y axis)
3	Clamp height 76 mm with parallel upper and conical lower fit
4	Upper cylindrical and lower conical contact face

As shown in the diagram, the clamp height has been increased on the Z-axis from 52 mm on the E9x series model (left) to 76 mm on the E9x M3 (right).

The front spring strut now has an additional support. The wheel carrier has also been modified to compensate for the increased drive and dynamic forces.

The lower contact face of the spring strut in the E9x M3 has a cone, which is positioned firmly in the wheel carrier. In E9x vehicles, however, the front spring strut has a parallel construction and is only held in place by the clamping force.

This design change and the increased clamp height accommodate the increased reaction forces of the spring strut and increase the overall stability of the wheel suspension.

During assembly, the M3 spring strut is pulled into the lower cone using a new special tool.

**Note: Follow the installation and removal process according to the service repair instructions.**

### Tension Strut

The tension strut is similar to that used in the E9x series vehicles, but features an 'M'-specific harder rubber mount.

### Wishbone

The M control arm is completely new and is connected to the axle carrier and wheel carrier by two ball joints. It is manufactured out of forged aluminum alloy.

### Wheel Bearing Unit

The M3 wheel bearing unit is identical to the E60 M5 wheel bearing unit. It has three dowel pins for the brake disc.



### Front Anti-roll Bar

The weight-optimized front anti-roll bar was adapted for the M3 and has a special rubber bearing material for more direct response. The hinged brackets are made out of an aluminum alloy (steel in E9x series vehicles).



## Steering System

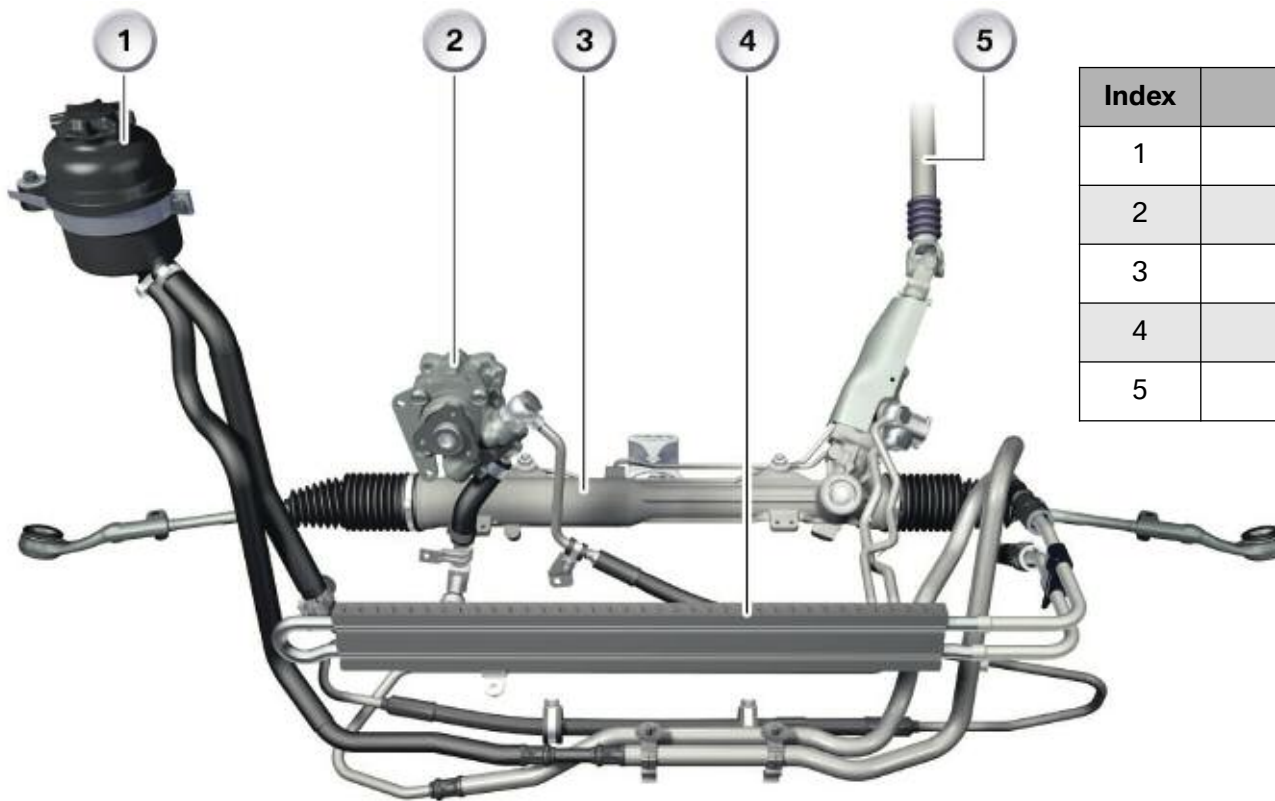
The design of the rack-and-pinion steering system is the same as in the E9x series vehicles. The average variable overall ratio is 12.5 (sports-oriented compared to 16 in the E9x series).

In the M3, the steering force support is controlled by the MSS60 via the Servotronic valve. A speed dependent characteristic curve is stored in the MSS60 for this purpose. With the MDrive menu

option, a second and even more sports oriented characteristic curve can be activated (see the chapter on MDrive).

The steering oil is guided through the steering oil cooler before it returns to the oil reservoir.

The E9x M3 is not available with active steering.



Index	Explanation
1	Steering oil header tank
2	Steering oil hydraulic pump
3	Steering transmission housing
4	Steering oil cooler
5	Steering wheel spindle

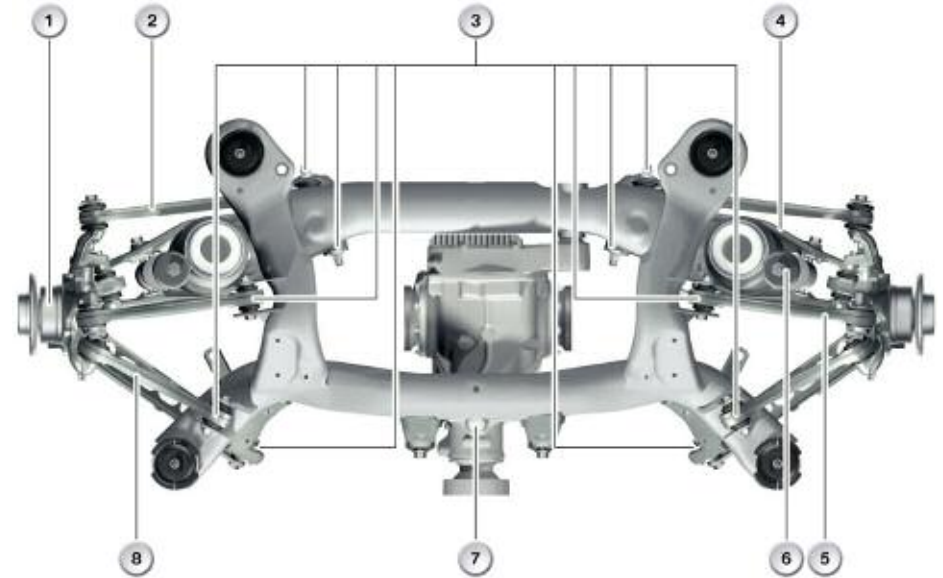
## Rear Axle

The rear axle carrier is constructed from steel sections which are welded together. All mounting points for the rear axle and suspension components are formed or attached to the axle carrier making it an integral component.

Nearly all components of the rear chassis have been revised, the aim is to achieve optimum sports vehicle kinematics, chassis stabil-

ity and a more precise and direct response, with a simultaneous reduction in weight.

This has been achieved by the careful selection of materials for the axle components and bearings, and through a modification of the axle geometry.



Designation	E92 M3	Series E92 335i
Tire type/Wheel rim type/Rim offset [mm]	265-40 ZR 18/9.5Jx18 / IS23	225-45 WR 17 RSC/8Jx17/ IS34
Tire radius [mm]	311	295
Wheelbase [mm]	2761	2760
Track width [mm]	1539	1513
Total toe	10'	18'
Driving axis angle	0°	0°
Camber	-1° 45'	-1° 30'

### Construction of Rear Axle

Index	Explanation	Index	Explanation
1	Wheel carrier	5	Wishbone
2	Toe struts	6	Shock absorber
3	Connections from control arm to rear axle carrier	7	Rear axle carrier
4	Camber struts	8	Traction strut with semi-trailing arm below it

## Wheel Carrier

The attachment points for toe, camber, wishbone, longitudinal and traction struts have been positioned specifically for the 'M' model.

Its overall dimensions allow for the larger M wheel to be fitted. The 'M' wheel carrier is fitted with a modified rubber mount connecting to the semi-trailing arm and a ball joint for the camber strut.

## Toe Struts

The new 'M' toe strut is forged from Aluminum. It is one-piece and has two integrated ball joints.

## Camber Struts

The 'M' camber strut is a new lightweight component forged from Aluminum. Its design reduces the unsprung mass of the vehicle.

## Wishbone

The new 'M' wishbone is forged from aluminum and has a modified integrated ball joint and a rubber mount.

## Control Strut

The semi-trailing arm is the only rear suspension strut that is taken from the E9x vehicles. It is connected further inwards on the rear axle carrier, only the rubber mount is new.

## Traction Strut

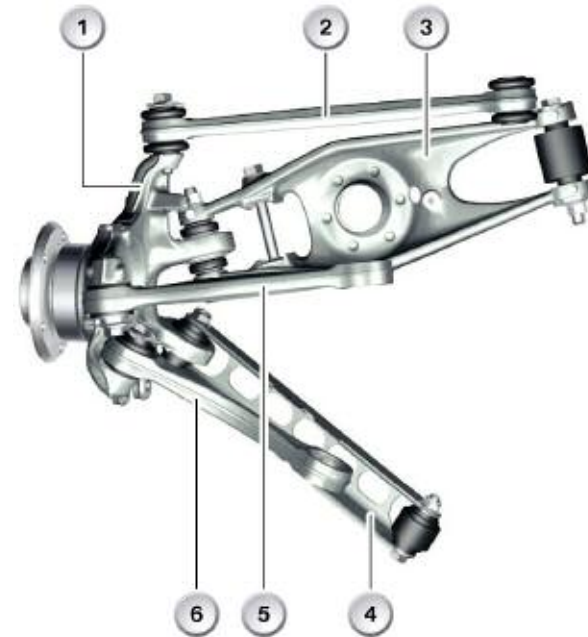
The geometry of the forged aluminum 'M' traction strut has been revised. It now has a new integrated rubber mount for the wheel carrier. The ball joint for the rear axle carrier has been taken from the E9x series vehicles .

## Rear Shock Absorbers

New 'M' specific rear aluminum dampers are fitted to the M3. Electronic damper control - continuous (EDC-K), is available as an option.

The integrated lower damper rubber mount has a support sleeve that improves the rigidity and stability between the damper and the camber strut.

### Overview of rear axle struts



Index	Explanation
1	Wheel carrier
2	Toe strut
3	Camber strut
4	Control strut
5	Wishbone
6	Traction strut

## Electronic Damper Control - Continuous (EDC-K)

EDC-K is available for the first time in the E9x M3. EDC-K is an option and is based on the EDC-K in the E65 and E60 M5.

Both dampers of one axis are always activated in parallel. The valve is installed internally in the damper in the damper oil system.

The compression phase, and in particular the rebound phase, of the shock absorbers can be adjusted by the EDC-K depending on the input signals in a smooth transition from relatively comfortable to a harder sports setting.

The driver can choose between three settings, the controlled programs "Comfort" and "Normal", or the uncontrolled fixed setting "Sport".

The program is selected using the EDC-K button on the center

console or preset via the MDrive menu and activated using the M button on the steering wheel (for more information, see the MDrive chapter).

The input signals come from two vertical acceleration sensors in the front wheel arches and a third sensor in the rear right-hand wheel arch.

The steering column switch cluster sends the steering angle to the F-CAN. This is transmitted together with the wheel speeds from the DSC to the PT-CAN and evaluated in the EDC-K control unit.

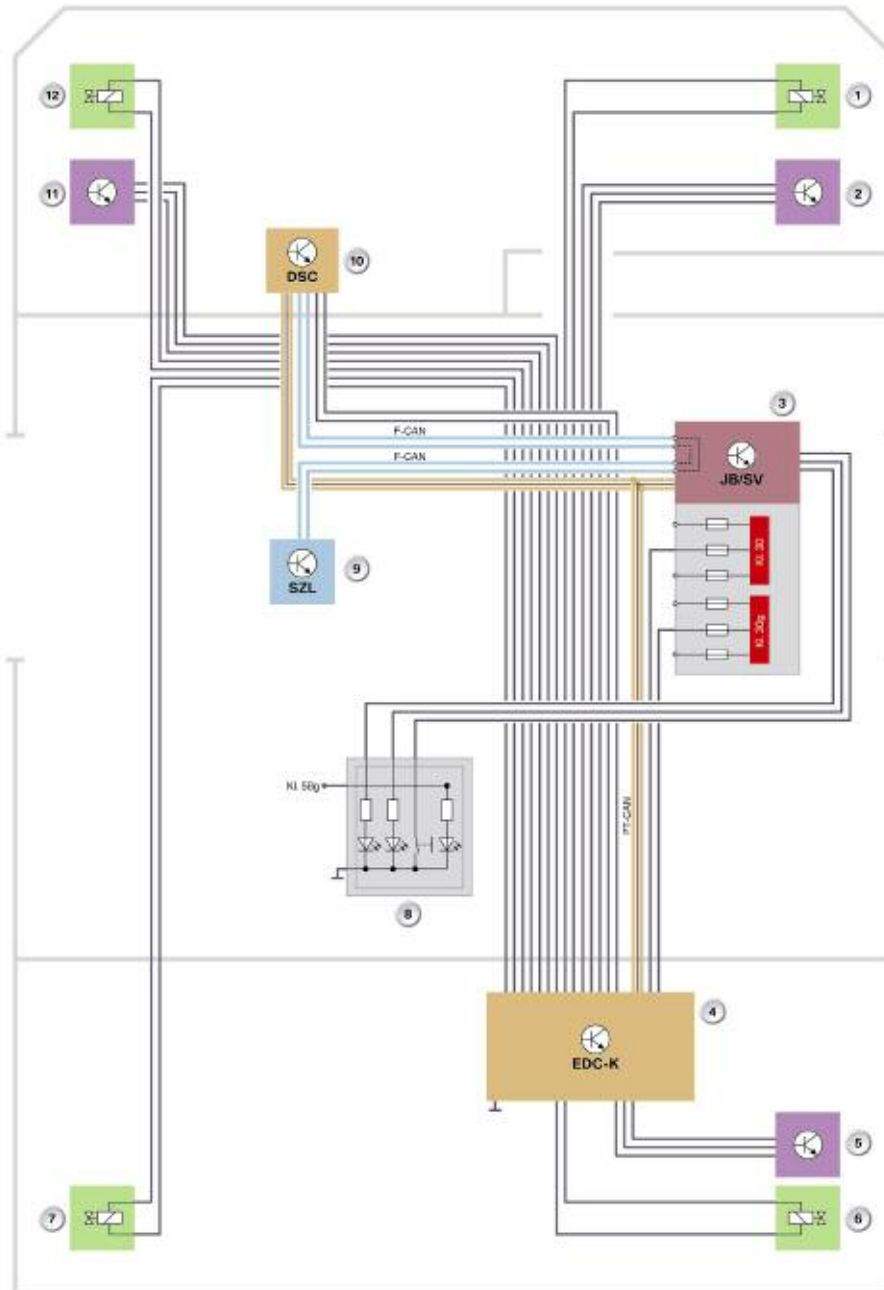
The longitudinal, lateral and vertical accelerations calculated as a result are used as a basis for regulation.

The EDC-K button signal enters the junction box and is transmitted to the EDC-K on the PT-CAN.





## EDC-K System Circuit Diagram



Index	Explanation
1	EDC valve, front right
2	Vertical acceleration sensor, front right
3	Junction box/distribution box
4	EDC-K control unit
5	Vertical acceleration sensor, rear left
6	EDC valve, rear right
7	EDC valve, rear left
8	EDC button on center console
9	Steering column switch cluster
10	DSC control unit
11	Vertical acceleration sensor, front left
12	EDC valve, front left

## Wheels and Tires

In the standard version, the cast 18" 'M' double spoke wheel (style 260) is available for the E9x M3, with the forged and polished 19" 'M' double-spoke wheel (style 220) available as an option. These are weight-optimized M3 light alloy wheels.



The tires are also specifically selected for the M3. The Michelin Pilot Sport (PS2\*) is currently fitted.

### Wheel/tire Specification

#### Standard wheel:

Front - Wheel: 8.5 J x 18; IS 29; EH2+  
Tires: 245-40 ZR 18

Rear - Wheel: 9.5 J x 18; IS 23; EH2+  
Tires: 265-40 ZR 18

#### Optional:

Front - Wheel: 8.5 J x 19; IS 29; EH2  
Tires: 245-35 ZR 19 XL

Rear - Wheel: 9.5 J x 19; IS 23; EH2  
Tires: 265-35 ZR 19 XL

## Brakes

The M Compound brake system with perforated brake discs and three 'M'-typical brake pad wear sensors is used, with a specifically adapted operating principle and dimensions.. The diameter of the brake discs has increased compared to the E46 M3 by 35 mm at the front, and by 22 mm at the rear.



### Brake System Specification

**Front brake:** Diameter 360 mm, thickness 30 mm, direction-specific ventilation, single-piston floating caliper (light-weight metal alloy), brake pad wear sensor right and left.

**Rear brake:** Diameter 350 mm, thickness 24 mm, direction-specific ventilation, internal handbrake with 185 mm diameter (similar to E60 M5), single-piston floating caliper (cast metal alloy), brake pad wear sensor on right.



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## **Dynamic Stability Control (DSC) MK60E5**

The E9x M3 is equipped with the MK60E5 DSC system made by Continental Teves, which has been specifically adapted to its driving dynamics. The "civilian" version is installed in several non-M models.

The fundamental difference in both versions is the replacement of Dynamic Traction Control (DTC) with M Dynamic Mode (MDM). MDM has been adapted to suit sports car dynamism for experienced sports drivers. The permitted float angle and longitudinal slip in good environmental conditions (road, weather, etc.) are also equally high.

Furthermore, the driving-performance control (FLR), soft stop and Fading Brake Support (FBS) functions are not required in the 'M' version.

The braking readiness (applies the foot brake and the handbrake until the discs and drums are dry) and the gradient assistant functions have been adapted appropriately.

**Note: An M-specific version of the MK60E5 is installed in the E6x M5 and M6. For further information regarding DSC systems refer to the Chassis Dynamics training material available in TIS and ICP.**

NOTES

PAGE